JP05061421A

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DIRECT CURRENT DRIVEN PLANE DISPLAY DEVICE

NIPPON MEKTRON LTD

Inventor(s): ; TOYAMA JIRO ; AKATSUKA TAKATOSHI ; TADAKUMA AKIRA ; MORI TAKASHI

Application No. 03244453, **Filed** 19910829, **Published** 19930312

Abstract: PURPOSE: To obtain the DC driven plane display device which can prevent the deterioration in properties of a display liquid generated by the transfer and receipt of charges between the display liquid and electrodes by coating the surfaces of the electrodes in contact with the display liquid of the plane display device, such as electrophoretic display device, with an insulator, thereby shutting off a direct current.

CONSTITUTION: The plane display device which is sealed with the liquid or solid for display of the optical characteristics changing with the direct current has insulating layers 6, 7 formed on at least one surface of the electrodes 2, 4 facing each other and is so constituted that the max. value of the voltage applied on the insulating layers 6, 7 is smaller than the product of the breakdown strength of the insulating layers 6, 7 and the film thickness.

Int'l Class: G09F00937

MicroPatent Reference Number: 000218139

SHUSAKU YAMAMOTO

Your Ref: 2108/2
Japanese Laid-Open Publication No. 5-61421

(Translation)

Japanese Laid-Open Publication Number: 5-61421
Japanese Laid-Open Publication Date: March 12, 1993
Title of the Invention: DC-DRIVEN PLANAR DISPLAY DEVICE
Application Number: 3-244453
Filing Date: August 29, 1991
Inventors: J. SOTOYAMA et al.
Applicant: NIPPON MEKTRON KABUSHIKI KAISHA

Specification

[Title of the Invention] DC-DRIVEN PLANAR DISPLAY DEVICE

[Claim]
[Claim 1] A DC-driven planar display device, comprising a liquid or solid for display, optical characteristics of which are changed by a DC current, provided in a sealed state in a space between electrodes opposed to each other, the DC-driven planar display device being characterized in that an insulating layer is provided on a surface of at least one of the electrodes opposed to each other, and a maximum voltage value applied to the insulating layer is smaller than the product of a dielectric breakdown strength and a thickness of the insulating layer.

[Detailed Description of the Invention]
[0001]
[Field of the Invention] The present invention relates to a DC-driven planar display device such as an electrophoresis display device, in which a surface of an electrode in contact with a display liquid is coated with an insulating material so as to block a DC current, and thus the quality

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change of the display liquid caused by transfer of charges between the display liquid and the electrode is prevented.

[0002]
[Prior Art and its Problems] As shown in Figure 4, a DC-driven planar display device such as an electrophoresis display device includes two transparent substrates 1 and 3 which are formed of glass or the like and respectively have electrodes 2 and 4 formed on surfaces thereof opposed to each other. The transparent substrates 1 and 3 are opposed to each other with a prescribed distance kept therebetween. A display liquid 5 including a dispersion medium colored with a dye and pigment particles is sealed in a space between the substrates 1 and 3. A DC voltage is applied to the electrodes 2 and 4 opposed to each other so as to generate a DC electric field in the display liquid 5 and move the pigment particles thus charged. Thus, a desired display is realized while changing the distribution of the pigment particles.

[0003] However, the application of the DC voltage generates an electric field in the display liquid 5 and also generates a DC current in a circuit connecting the display liquid 5, the electrode 2 and 4, and a power supply. The specific resistance of the display liquid 5 used in an electrophoresis display device is usually $10^8\Omega\cdot cm$ or more, which is relatively high, and the DC current thereof is several microamperes per square centimeters, which is relatively small. The influence of the DC current on the reliability regarding the long life of the device is quite significant.

[0004] In other words, an inflow of electrons from outside the display liquid 5 or outflow induces the oxidation and reduction of the display liquid, which causes instability,

specific to DC driving display devices. The instability is caused due to factors such as, for example: a display change caused by a quality change in the dye: or a quality change of the surfactant used for dispersing the electrophoretic particles: extinction of the electrode caused by dissolution of the electrode components into the display liquid: or a combination of these obstacles.

[0005] In a conventional electrophoresis display device, various attempts have been made to improve the reliability during the term during which the device can be practically usable. Such attempts include, for example, increasing the specific resistance of the display liquid to reduce the DC current so that the life of the device is extended; and adopting a voltage application system which avoids superimposing of DC voltages as described in Japanese Patent Application No. 2-8875 filed by the Applicant of the present application. However, such means cannot be considered to be provide a fundamental solution and are not sufficient. According to such means, for example, the life is different based on the lot of the material: or the usable dyes, surfactants and the usable amounts are restricted, and thus the display quality itself is deteriorated.

[0006] In the case of, for example, AC-driven display devices such as liquid crystal display devices and AC-driven plasma display devices, a dielectric film is provided on a surface of the electrode in order to prevent deterioration of the display and inflow of charges into the electrode as well as to achieve other aims. In the case of a DC-driven display device, such a system is not adopted because a continuous application of a DC voltage for maintaining the display accumulates the charges in the dielectric film, which prevents effective application of the electric field on the

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display medium or causes dielectric breakdown of the dielectric film.

[0007]
[Objective and Structure of the Invention] The present invention is to provide a DC-driven planar display device for preventing quality change of a display liquid caused by transfer of the charges between the display liquid and the electrode, by blocking of a DC current by coating a surface of the electrode in contact with the display liquid with an insulating material.

[0008] In order to achieve the above-described objective, a DC-driven planar display device according to the present invention includes a liquid or solid for display, the optical characteristics of which are changed by a DC current, provided in a sealed state in a space between electrodes opposed to each other. The DC-driven planar display device includes an insulating layer provided on a surface of at least one of the electrodes which are opposed to each other, and is structured so that the maximum voltage value applied to the insulating layer is smaller than the product of a dielectric breakdown strength and a thickness of the insulating layer.

[00091
[Examples] Figure 1 is a conceptual enlarged cross-sectional view of an important part of a DC-driven planar display device structured in accordance with the present invention. In the Figure, identical reference numerals as those in Figure 4 represent identical elements. In Figure 1, electrodes 2 and 4, required for display, are formed of a conductive material such as, for example, indium tin oxide and provided on surfaces of transparent substrates 1 and 3 which are op-

posed to each other. The electrodes 2 and 4 are connected to an external power supply outside the transparent substrates 1 and 3 through leads not shown.

[0010] The electrodes 2 and 4 and parts of the leads are coated with insulating layers 6 and 7 which are formed separately in accordance with the present invention. Usable as the insulating materials 6 and 7 are, for example, insulating polymers such as polyethylene, polyimide, ethylene tetrafluoride and the like: and insulating metal oxides such as silicon oxide, barium titanate, titanium oxide and the like. The insulating layers 6 and 7 can be appropriately formed by a usual film formation method such as coating, printing, LB film formation, deposition, sputtering or the like. An electrophoresis display device as a DC-driven planar display device is completed by putting the display liquid 5 between the electrodes 2 and 4, provided with the insulating layers 6 and 7 in a conventional manner, and sealing the periphery of the transparent substrates 1 and 3 with an adhesive.

[0011] When a DC voltage is applied to the electrodes 2 and 4 of the above-described display device, the insulating layers 6 and 7 formed on the surfaces of the electrodes 2 and 4 act as an equivalent capacitance connected in series to an equivalent resistance of the display liquid 5 and thus suppress inflow of DC current components from the display liquid 5 to the electrodes 2 and 4 and outflow.

[0012] In other words, when the electrodes 2 and 4 are coated with the insulating layers 6 and 7 formed of a highly dielectric material, the film thickness is made sufficiently small to make the equivalent series capacitance sufficiently large, so as to make the time constant determined by the

equivalent series capacitance and the specific resistance of the display liquid 5 sufficiently larger than the response time of the display device, the voltage applied to the display device within the response time can be maintained to be constant and substantially equal to the applied voltage. Moreover, since the display liquid 5 is not in contact with the electrodes 2 and 4, the above-described outflow of the charges can be restricted.

[0013] The equivalent capacitance can be set to be large. However, needless to say, when operating voltage pulses having the same polarity are continuously applied, the coating film is charged and thus the level of the voltage applied to the display device is reduced. As a result, the display function of the display device cannot be maintained.

[0014] An electrophoresis display device according to the present invention has a memory function which is perfect for display and thus does not require application of voltages of the same polarity for maintaining the display. Therefore, application of the pulses of the same polarity can be restricted as in the case of the technology described in Japanese Patent Application No. 2-8875. Accordingly, the present invention can be carried out in consideration of the response time of the display: and the dielectric constant, thickness and the withstand voltage of the coating films formed of the insulating layers 6 and 7. Thus, the electrochemical reaction of the display device can be restricted. Hereinafter, the case in which the above-described insulating layer is formed on one of the electrodes will be described.

[0015] This type or similar types of insulating layers or protection layers of an insulating substance formed on elec-

trode surfaces are known in the case of AC-driven display devices. An insulating layer according to the present invention, which is required to have capabilities specific to DC-driven display devices, is essentially different from the conventional insulating layers. In other words, insulating layers in the AC-driven display devices include, for example, a polymer alignment layer used in liquid crystal display devices and a magnesium oxide protection layer used in AC plasma display devices. The former is used for alignment, and the latter has a function as an ion impact alleviator or a secondary electron supplying layer, which are different from formation of a capacitance for inhibiting a DC current. The withstand voltage V_{IX} required for a conventional protection layer is expressed by the following expression and is different from that of the insulating layer according to the present invention.

$$V_{IX} = \frac{\varepsilon_0 / d_0}{\varepsilon_{IX}/d_{IX} + \varepsilon_0/d_0} \times E$$

where E is the peak value of the applied AC voltage, ε_{IX} is the dielectric constant of the protection layer, d_{IX} is the thickness of the protection layer, ε_0 is the dielectric constant of the display liquid, and d_0 is the thickness of the display liquid.

[0016] The voltages applied to the insulating layer and the display liquid 5 for generating a display by applying the voltages to the display device according to the present invention can be found by obtaining a transient response resolution with the equivalent circuit shown in Figure 2. When a display pulse having a voltage E and a pulse width t_{PE} which is required for display is applied in the state of zero initial charge, voltage Vp applied to the display liquid 5 is expressed by:

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$$V_r = \frac{C_1E}{C_1+C_2} \exp\left(-\frac{C_1+C_2}{rC1C2}t\right) + \frac{C_1E}{C_1+C_2} \exp\left(-\frac{1}{R(C_1+C_2)}t\right)$$

where C_1 is an equivalent capacitance of the insulating layer, C_2 is an equivalent capacitance of the display device, R is an equivalent resistance of the display liquid 5, r is an intra-power supply resistance and wire equivalent resistance, and E and -E are each an operating voltage pulse.

[0017] In the above expression, when r based on the wire and intra-power supply resistance is small, the first term of the expression is a transient term corresponding to the boosting period from a voltage of zero and thus becomes a negligible value within a short time period. Consequently, the value of the second term is applied to the display liquid 5. In the case where the C,, i.e., the capacitance of the insulating layer is designed to be large so that $R(C_1+C_2)$ is sufficiently larger than the pulse width t_{PE} required for display, Vp is substantially $C_1E/(C_1+C_2)$ where $C_1 \gg C_2$. Accordingly, **Vp=E.** This value of Vp is equal to that in the case where no insulating layer is provided. Characteristically, unlike the case with no insulating layer, the pigment particles in the display liquid and electrons and ions in the solvent do not provide the electrode with charges, and only the spatial positions thereof are changed without the quality thereof being changed by oxidation or reduction reaction.

[0018] A voltage V_I applied on the insulating layer is determined in a similar manner, and the maximum value thereof is:

$$V_I = E - \frac{C_1E}{C_1+C_2} \exp\left(-\frac{1}{R(C_1+C_2)}t_{PE}\right)$$

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The insulating layer structured according to the present invention needs to be designed to have a withstand voltage equal to or greater than V,.

[0019] The expression can be represented as follows using the area S of the insulating layer, the thickness d_1 of the insulating layer, the dielectric constant ε_1 of the insulating layer, the area S of the display liquid, the thickness d_0 of the display liquid, the dielectric constant ε_0 of the display liquid, and the specific resistance R_0 of the display liquid.

$$V_1 = E - E \times \frac{d_0 \cdot \varepsilon_1}{d_0 \cdot \varepsilon_1 + d_1 \cdot \varepsilon_0} \mathrm{em} \left(\frac{t_{PR}}{(\varepsilon_0 + \varepsilon_1 . d_0 / d_1) R_0} \right)$$

Namely, the dielectric breakdown strength of the insulating layer $\times d_1 > V_I$.

[0020] When, for example, an SiO_2 insulating layer having $\varepsilon_1 = 4 \times 0.0885 \times 10^{-12}$(F/cm) and $d_1 = 0.1 \times 10^{-4}$(cm) is provided in an electrophoresis display device having $d_0 = 50 \times 10^{-4}$(cm), $\varepsilon_0 = 3 \times 0.0885 \times 10^{-12}$(F/cm), $R_0 = 10^{11}$($\Omega \cdot$cm) and a response speed of 100 $\times 10^{-3}$(sec.), V_I is about -0.28 V. By contrast, the dielectric breakdown strength of the insulating material is about 30 kV/mm, and the insulation strength of the insulating layer is 3 V, which are sufficient to withstand V_I. The constants regarding the electrophoresis display device calculated above by way of trial are average constants of trial products produced so far. Even materials having constants different from the above constants can be selected in consideration of the dielectric constant and dielectric breakdown strength of the insulating layer to be formed.

[0021] Hereinafter, voltages of various parts obtained when a pause pulse having a voltage of zero is applied after the

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above-described display pulse is applied will be described. Where t is the time period after the applied voltage is made zero, the voltage Vp applied to the display liquid is

$$V_{P-} = \frac{C_1 B}{C_1 + C_2} \left(1 - \exp\left(-\frac{1}{R(C_1 + C_2)} t_{PB}\right) I \exp I - - \frac{1}{R(C_1 + C_2)} t\right)$$

Since C_1 is set so that $R(C_1+C_2)$ is sufficiently larger than t_{PB}, the absolute value of V_{P-} is too small to have any influence on the display. When R_S which is larger than R is set to restrict the charge inflow from C_1 to C_2 in order to alleviate the application of the opposite polarity voltage on the display device, as shown in Figure 3, the value of V_{P-} can be further reduced.

[0022] The display device including the above-described insulating layer is driven effectively utilizing the memory for display so that the superimposing application of the voltage pulses having the same polarity, which is described in Japanese Patent Application No. 2-8875, is prevented and thus the excessive charging of the insulating layer is prevented. Accordingly, an element which has been once displayed is supplied with a voltage having an opposite polarity for discharging the charges of the insulating layer, and thus the voltage applied to the insulating layer does not exceed the value of V_I described above.

[0023] In the above, required conditions for the insulating layer and specific examples of the driving methods for a DC-driven planar display device including an insulating layer on either one of the electrodes 2 and 4 are described. The counter electrode can also be coated with a similar insulating layer, and this is preferable for improvement of performance, which is an objective of the present invention.

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[0024] An electrophoresis display device is described in the above as an example of DC-driven planar display devices, but the present invention is also applicable to other types of DC-driven planar display devices having a memory function such as, for example, an electrochromic display device,

[Effect of the Invention] A DC-driven planar display device according to the present invention, as can be apparent from the above description, coats a surface of an electrode in contact with the display liquid with an insulating material to block the DC current. Thus, quality change caused by transfer of charges between the display liquid and the electrode, i.e., the quality change of the display liquid caused by oxidation and reduction of ions in the display liquid can be prevented.

[0026] Accordingly, the color change of the dye, deterioration of the dispersion state, change of the electrophoresis characteristics of the dispersion particles, and the like can be prevented.

[Brief Description of the Drawings]
[Figure 1] A conceptual cross-sectional view of a DC-driven planar display device structured according to one example of the present invention.

[Figure 2] An equivalent circuit diagram in the case where an insulating layer is formed on one of the electrodes in Figure 1.

[Figure 3] An equivalent circuit diagram in the case where an external resistor is provided in Figure 2.

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[Figure 4] A conceptual enlarged cross-sectional view of an important part of a conventional electrophoresis display device.

[Description of Reference Numerals]

1 Transparent substrate
2 Electrode
3 Transparent substrate
4 Electrode
5 Display liquid
6 Insulating layer
7 Insulating layer

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[Abstract]
[Objective] To provide a DC-driven planar display device, such an electrophoresis display device, for preventing a quality change of a display liquid caused by transfer of charges between the display liquid and an electrode, by blocking a DC current by coating a surface of the electrode in contact with the display liquid with an insulating material.

[Structure] A planar display device including a liquid or solid, the optical characteristics of which are changed by a DC current, provided in a sealed state between electrodes opposed to each other. The planar display device includes an insulating layer formed on a surface of at least one of the electrodes which are opposed to each other, and is structured so that the maximum value of the voltage applied to the insulating layer is larger than the product of the dielectric breakdown strength and the thickness of the insulating layer.

(19)日本国特許庁（JP）　(12)公開特許公報(A)　(11)特許出願公開番号

特開平5－61421

(43)公開日　平成5年(1993)3月12日

(51)Int.Cl.5	識別記号	庁内整理番号	FI	技術表示箇所
G09F　9/37	311　A	7926－5G		

審査請求　未請求　請求項の数1（全5頁）

(21)出願番号　特願平3－244453

(22)出願日　平成3年(1991)8月29日

(71)出願人　000230249
日本メクトロン株式会社
東京都港区芝大門1丁目12番15号

(72)発明者　外山　二郎
茨城県稲敷郡茎崎町天宝喜757　日本メクトロン株式　会社南茨城工場内

(72)発明者　赤塚　孝寿
茨城県稲敷郡茎崎町天宝喜757　日本メクトロン株式　会社南茨城工場内

(72)発明者　多田隈　昭
茨城県稲敷郡茎崎町天宝喜757　日本メクトロン株式　会社南茨城工場内

(74)代理人　弁理士　鎌田　秋光

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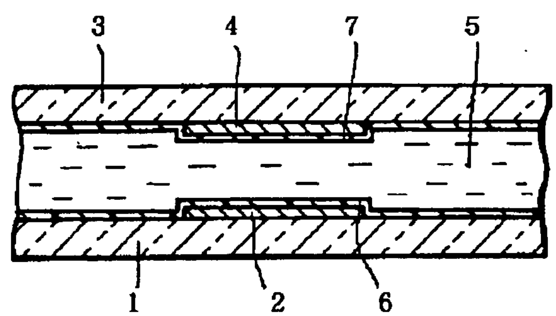
(54)【発明の名称】　直流駆動平面表示装置

(57)【要約】

「目的」　電気泳動表示装置などの平面表示装置で、表示液に接する電極表面を絶縁物で被覆して直流電流を遮断することにより、表示液と電極の電荷の授受によって生ずる表示液の変質を防止できる直流駆動平面表示装置を提供する。

「構成」　直流電流により光学的特性が変化する表示用の液体又は固体を対向配置した電極の間隙に封入した平面表示装置に於いて、対向する該電極の少なくとも一方の面に形成した絶縁層を備え、該絶縁層に加わる電圧の最大値が該絶縁層の絶縁破壊強度と膜厚の積より小さくなるように構成したもの。



【特許請求の範囲】

【請求項1】　直流電流により光学的特性が変化する表示用の液体又は固体を対向配置した電極の間隙に封入した平面表示装置に於いて、対向する該電極の少なくとも一方の面に形成した絶縁層を備え、該絶縁層に加わる電圧の最大値が該絶縁層の絶縁破壊強度と膜厚の積より小さくなるように構成したことを特徴とする直流駆動平面表示装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、電気泳動表示装置等の平面表示装置に於いて、表示液に接する電極表面を絶縁物で被覆して直流電流を遮断することにより、表示液と電極の電荷の授受によって生ずる表示液の変質を防止するようにした直流駆動平面表示装置に関する。

【0002】

【従来技術とその問題点】電気泳動表示装置等の直流駆動平面表示装置では、図4の如く、対向面に各別に電極2、4を形成したガラス板等の二枚の透明基材1、3を所定の間隔で対向配置し、その間隙内に染料で着色した分散媒と顔料粒子からなる表示液5を封入し、対向する電極2、4に直流電圧を印加して表示液5の内部に直流電界を発生させて荷電した顔料粒子を移動させてその分布を変化させながら所望の表示を行わせるものである。

【0003】しかし、直流電圧の印加は、表示液5の内部に電界を発生させるだけでなく、表示液5、電極2、4及び電源を結ぶ回路に直流電流を生じさせる。ところで、電気泳動表示素子に用いられる表示液5の固有抵抗は通常10^{8}Ω・cm以上と比較的高い抵抗値であり、その直流電流は数μA／cm^{2}以下の低い値であるが、この直流電流による長期寿命信頼性への影響は非常に大きい。

【0004】即ち、表示液5への外部からの電子の流入又は流出は、表示液の酸化・還元を誘起し、例えば、染料の変質による表示の変化、又は粒子分散の為の界面活性剤の変質、或いは電極成分の表示液への溶解による電極の消失、またこれらの障害の組み合わせ等、直流駆動表示素子特有の不安定性の原因となっている。

【0005】従来、電気泳動表示装置では、表示液の固有抵抗を高くして直流電流を低下させることにより延命効果をねらったり、或いは本願の出願人の提案による特願平2－8875号出願の如く直流電圧の重畳を避ける電圧印加方式を採用する等、実用期間での信頼性改善を図っている。しかし、このような手段は基本的な対策とは云えず、例えば、材料のロットによる寿命の変動や、或いは使用する染料、界面活性剤の種類や使用量に制限を生じ、表示性能そのものを劣化させるなど、不十分である。

【0006】例えば液晶表示素子、交流駆動プラズマ表示素子等の交流駆動表示素子では、他の目的と共に電極による表示の劣化、電荷の電極への流入を防止するために、電極表面に誘電体膜を設けて表示の劣化を防止することはあるが、直流駆動方式による表示素子では、表示を維持する為に直流電圧を継続して印加すると誘電体膜に電荷が蓄積し、表示媒体に電界を有効に印加できなくなったり、誘電体膜が絶縁破壊するなどの理由でこの方法は採用されていなかった。

【0007】

【発明の目的及び構成】本発明は、表示液に接する電極表面を絶縁物で被覆して直流電流を遮断することにより、表示液と電極の電荷の授受によって生ずる表示液の変質を防止するようにした直流駆動平面表示装置を提供するものである。

【0008】その為に、本発明に係る直流駆動平面表示装置は、直流電流により光学的特性が変化する表示用の液体又は固体を対向配置した電極の間隙に封入した平面表示装置に於いて、対向する該電極の少なくとも一方の面に形成した絶縁層を備え、該絶縁層に加わる電圧の最大値が該絶縁層の絶縁破壊強度と膜厚の積より小さくなるように構成したものである。

【0009】

【実施例】図1は、本発明に従って構成された直流駆動平面表示装置の概念的な要部拡大断面構成図であって、図中、図4と同一符号はそれらと同一の構成要素を示す。図1に於いて、表示に必要な電極2、4は透明基材1、3の対向面にインジュウム錫酸化物等の導電材料で形成され、この電極2、4に図示しない引き出し線を接続して透明基材1、3の外部に導出することにより外部電源に接続するものである。

【0010】上記電極2、4及び引き出し線の一部にはそれらを被覆するように本発明に従って絶縁層6、7が各別に形成される。この絶縁層6、7の材料としては、ポリエチレン、ポリイミド、四フッ化エチレン等の絶縁性高分子、或いは酸化圭素、チタン酸バリウム、酸化チタン等の絶縁性金属酸化物を使用できる。また、それら絶縁層6、7の形成手段としては、塗布、印刷、LB製膜、蒸着又はスパッタ等の通常の膜形成手法を適宜採用できる。そして、直流駆動平面表示装置としての電気泳動表示素子を構成するには、上記の如き絶縁層6、7を有する電極2、4の間隙内に従前のように表示液5を封入して透明基材1、3の周囲を接着剤で封着することにより完成できる。

【0011】上記表示装置の両電極2、4に直流電圧を印加する場合、電極2、4の表面に形成された絶縁層6、7は、表示液5の等価抵抗に直列の等価静電容量として働き、表示液5からの直流電流成分の電極2、4への流入、流出を抑止する。

【0012】即ち、電極2、4の表面を上記のような高誘電体材料からなる絶縁層6、7で被覆し、その膜厚を充分薄くして、この等価直列容量を充分大きく形成し、

その等価直列容量と表示液5の固有抵抗で定まる時定数をこの表示装置の応答時間より充分長くすれば、この応答時間内で表示装置に加わる電圧は略印加電圧と等しく一定に保つことができ、且つ表示液5は電極2、4に接しないので既述の如き電荷の外部流出を抑止することが可能となる。

【0013】勿論、等価静電容量は大きく設定できるとは云え、同極の動作電圧パルスを連続して印加すると、その被覆膜には電荷が荷電して表示装置に加わる電圧は減少するので、本来の表示機能を維持できなくなる。

【0014】本発明が対象とする電気泳動表示装置は、表示に完全なメモリー機能を有し、表示を継続する為の同極電圧の印加は不要であって、特願平2－8875号に係る技術の如く同極パルスの抑制が可能である。従って、本発明はその表示の応答速度、絶縁層6、7からなる被覆膜の誘電率、膜厚、その絶縁耐電圧を配慮して実施することが可能であり、この表示装置の電気化学的反応を抑制することができる。以下、上記の絶縁層を電極の一方に形成した場合について説明する。

【0015】電極面に形成されるこの種の絶縁層或いは絶縁物質による保護層は、交流駆動表示装置では類似のものが知られているが、本発明に従った絶縁層の場合では、直流駆動表示装置特有の性能が要求されるので、そのような従来のものとは本質的に異なるものである。即＊ ＊ち、交流駆動表示装置に於けるこのような絶縁層には、例えば液晶表示装置に於ける高分子配向膜、交流プラズマ表示装置に於ける酸化マグネシウム保護層があるが、前者は配向に、そして後者はイオン衝撃緩和又は二次電子供給層としての機能を持ち、これは直流電流阻止の静電容量とは異なる。また、上記従来の保護層に要求される絶縁耐圧V_{IX}は、Eを印加交流電圧の尖頭値、ε_{IX}を保護層の誘電率、d_{IX}をその膜厚、ε_0を表示液の誘電率とし、d_0をその層厚とした場合、

$$V_{IX}=\frac{\varepsilon_0/d_0}{\varepsilon_{IX}/d_{IX}+\varepsilon_0/d_0}\times E$$

となり、本発明とは異なる。

【0016】実際に本発明の表示装置に電圧を印加して表示を行う際の絶縁層、表示液5に加わる電圧は、図2の等価回路でその過渡応答解を求めることによって求められる。初期電荷ゼロの状態で表示に必要な電圧E、パルス幅t_{PE}の表示パルスを印加した場合、表示液5に印加される電圧V_Pは、C_1を絶縁層の等価静電容量、C_2を表示装置の等価静電容量、Rを表示液5の等価抵抗、rを電源内部抵抗及び配線等価抵抗、そしてE及び－Eを動作電圧パルスとすれば、

$$V_P=-\frac{C_1E}{C_1+C_2}\exp\left(-\frac{C_1+C_2}{rC1C2}t\right)+\frac{C_1E}{C_1+C_2}\exp\left[-\frac{1}{R(C_1+C_2)}t\right]$$

で表される。

【0017】上式に於いて、配線及び電源内部抵抗に基づくrが小さい場合にはその第一項は電圧ゼロから昇圧する間の過渡項であって短時間で無視できる値となり、従って第二項が表示液5に印加される。ここで、R（C_1+C_2）が表示に必要なパルス幅t_{PE}に比べて充分大きくなるようにC_1、即ち絶縁層の静電容量を大きく設計すれば、V_Pは略$C_1E/(C_1+C_2)$、$C_1\gg C_2$でV_P※ ※＝Eとなって絶縁層のない場合と等しくなる。この場合、絶縁層のない場合と異なり、表示液中の顔料粒子及び溶媒中の電子やイオンは電極に電荷を与えることはなく、その空間位置が変位するだけで、これらが酸化還元反応により変質しないことが特徴である。

【0018】絶縁層に加わる電圧V_Iも同様に求まり、その最大値は、

$$V_I=E-\frac{C_1E}{C_1+C_2}\exp\left[-\frac{1}{R(C_1+C_2)}t_{PE}\right]$$

となり、本発明に従って構成される絶縁層の絶縁耐電圧はこのV_I以上となるように設計する必要がある。

【0019】この式を絶縁層の面積S、その層の膜厚d★ ★$_1$、誘電率ε_1、そして、表示液の面積S、厚みd_0、誘電率ε_0、その固有抵抗R_0を用いて表すと、

$$V_I=E-E\times\frac{d_0\cdot\varepsilon_1}{d_0\cdot\varepsilon_1+d_1\cdot\varepsilon_0}\exp\left[-\frac{t_{PE}}{(\varepsilon_0+\varepsilon_1\cdot d_0/d_1)R_0}\right]$$

となり、絶縁層の絶縁破壊強度×d_1＞V_Iとなる。

【0020】例えば、$\varepsilon_1=4\times0.0885\times10^{-12}$(F/cm)、$d_1=0.1\times10^{-4}$(cm)の$SiO_2$絶縁層を、$d_0=50\times10^{-4}$(cm)、$\varepsilon_0=3\times0.0885\times10^{-12}$(F/cm)、$R_0=10^{11}$(Ω·cm)、応答速度 100×10^{-3}（秒）の電気泳動表示装置に設けると、V_Iは約－0.28Vとなる。一方、絶縁層材料の絶縁破壊強度は約30kV／mmであって、また、絶縁層の絶縁強度は3Vであり、充分そのV_Iに耐え得る。以上試算した電気泳動表示装置の諸定数はこれまで試作された素子の平均的な定数であるが、これらと異なる場合でも、形成する絶縁層の誘電率及びその破壊強度を配慮して材料を選択することができる。

【0021】更に、先の表示電圧パルスを印加した後、電圧ゼロの休止パルスを印加した場合の各部電圧について述べる。印加電圧をゼロとした後からの時間をtとすると表示液に加わる電圧V_Pは、

$$V_{P-}=-\frac{C_1E}{C_1+C_2}\left[1-\exp\left(-\frac{1}{R(C_1+C_2)}t_{PE}\right)\right]\exp\left[-\frac{1}{R(C_1+C_2)}t\right]$$

の逆極性の電圧が加わるが、R（C_1+C_2）がt_{PE}より充分大きくなるようにC_1を設定しているので、このV_{P-}の絶対値は小さく、表示に影響しない。またこの逆極性の電圧の表示装置への印加を軽減する為に、図3の如く、Rより大きいR_Sを設置してC_1からC_2への電荷流入を抑制すれば、V_{P-}を更に低減することも可能である。

【0022】上記の如き絶縁層を設けた表示装置の駆動では表示のメモリーを有効に利用し、既述の特願平2－8875号の出願で具体化されるような同極電圧パルスの重畳印加の防止を行い、この絶縁層への過剰な荷電を防止するものである。従って、一旦表示を行ったエレメントには絶縁層の電荷を放電する逆極性の電圧が印加されることになり、この絶縁層に加わる電圧は先に述べたV_Iを越えることはない。

【0023】以上の説明は、絶縁層を電極2、4のいずれか一方に形成した場合の直流駆動平面表示装置に於けるその絶縁層に必要な条件、駆動方法の具体例を述べたものであるが、対向する対となる電極も併せて同様な絶縁層で被覆することも可能であり、且つ本発明の目的とする性能向上の点でも好ましい。

【0024】また、上記の説明は直流駆動平面表示装置として電気泳動表示装置について行ったが、例えばエレクトロクロミック表示装置など、メモリー機能を有する他の直流駆動平面表示装置にも適用することができる。

【0025】

【発明の効果】本発明に係る直流駆動平面表示装置は、以上の説明から明らかなように表示液に接する電極表面を絶縁物で被覆して直流電流を遮断することにより、表示液と電極の電荷の授受によって生ずる表示液の変質、即ち表示液中のイオンの酸化・還元による表示液の変質を防止できる。

【0026】従って、染料の変色、分散状態の劣化或いは分散粒子の電気泳動特性の変化等を防止できる。

【図面の簡単な説明】

【図1】　本発明の一実施例により構成された直流駆動平面表示装置の概念的な断面構成図。

【図2】　図1で絶縁層を一方の電極に形成した場合の等価回路図。

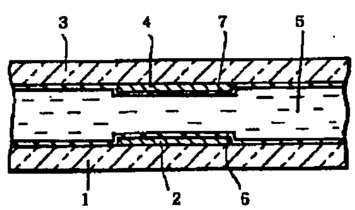
【図3】　図2で外部抵抗を設置した場合の等価回路図。

【図4】　従来の電気泳動表示装置の概念的な要部拡大断面構成図。

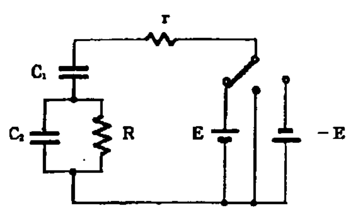
【符号の説明】

1　透明基材
2　電極
3　透明基材
4　電極
5　表示液
6　絶縁層
7　絶縁層

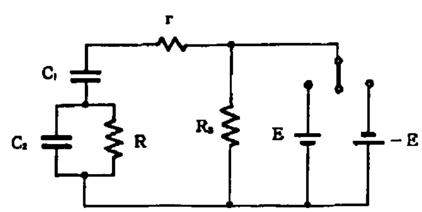
【図1】



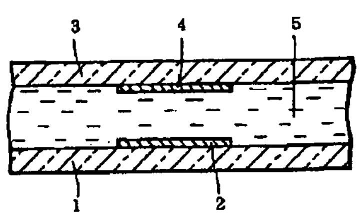
【図2】



【図3】



【図4】



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(72)発明者　森　高志
茨城県稲敷郡茎崎町天宝喜757　日本メクトロン株式　会社南茨城工場内